What is claimed is:

1.   A method for manufacturing a galvannealed steel sheet comprising the steps of:

preparing a hot-dip galvanized steel sheet consisting essentially of 0.05 to 0.30% C, 0.01 to 2.0% Si, 0.08 to 3.0% Mn, 0.003 to 0.1% P, 0 to 0.07% S, 0.01 to 2.5% Al, 0 to 0.007% N, by mass, and the balance being Fe and inevitable impurities;

applying alloying treatment to the hot-dip galvanized steel sheet; and

controlling time and temperature of the alloying treatment in accordance with the formula given below depending on the content of Si and of Al,

$$Si + Al \geq 1.5 \times 10^{-7} \times t^{0.75} \times (T - 465)^3 + 0.117$$

where t is the total time (sec) of holding the steel sheet at 465°C or higher temperature on alloying a coating layer thereon, and T is the average temperature (°C) of the steel sheet during the total time t (sec) of holding the steel sheet at 465°C or higher temperature on alloying the coating layer thereon.

2.   A method for manufacturing a galvannealed steel sheet comprising the steps of:

preparing a hot-dip galvanized steel sheet consisting essentially of 0.05 to 0.30% C, 0.01 to 2.0% Si, 0.08 to 3.0% Mn, 0.003 to 0.1% P, 0 to 0.07% S, 0.01 to 2.5% Al, 0 to 0.007% N, by mass, further at least one element selected from the group consisting of 0.01 to 2.0% Cr, 0.005 to 2.0% V, and 0.005 to 2.0% Mo, by mass, and balance of Fe and inevitable impurities;

applying alloying treatment to the hot-dip galvanized steel

sheet; and

controlling time and temperature of the alloying treatment in accordance with the formula given below depending on the content of Si, Al, Cr, Mo, and V,

$$Si + Al + 5 \times Cr + 15 \times Mo + 15 \times V \geqq 1.5 \times 10^{-7} \times t^{0.75} \times (T - 465)^3 + 0.117$$

where t is the total time (sec) of holding the steel sheet at 465°C or higher temperature on alloying a coating layer thereon, and T is the average temperature (°C) of the steel sheet during the total time t (sec) of holding the steel sheet at 465°C or higher temperature on alloying the coating layer thereon.

3. The method for manufacturing a galvannealed steel sheet according to claim 1, wherein the hot-dip galvanized steel sheet further contains at least one element selected from the group consisting of 0.01 to 0.1% Ti, 0.01 to 0.1% Nb, 0.0003 to 0.0050% B, 0.005 to 2.0% Ni, and 0.005 to 2.0% Cu, by mass.

4. The method for manufacturing a galvannealed steel sheet according to claim 2, wherein the hot-dip galvanized steel sheet further contains at least one element selected from the group consisting of 0.01 to 0.1% Ti, 0.01 to 0.1% Nb, 0.0003 to 0.0050% B, 0.005 to 2.0% Ni, and 0.005 to 2.0% Cu, by mass.